APPENDIX A

METHODS FOR THE DEVELOPMENT
OF SCREENING STANDARDS AND
MO-1, MO-2, AND MO-3 RECAP STANDARD

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A1.0 SOIL STANDARDS

The RECAP Soil Standards include $Soil_{ssni}$, $Soil_{ssi}$, $Soil_{SSGW}$, $Soil_{ni}$, $Soil_{i}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, $Soil_{GW3NDW}$, and $Soil_{sat}$. The Soil Screening Standards (Table 1), Management Option 1 RECAP Standards (Tables 2), and the Appendix H MO-2 RECAP Standards are based on: 1) the equations presented in this appendix; 2) toxicity values selected in accordance with the hierarchy defined in Section 2.4; 3) a target cancer risk and target hazard quotient as specified in Section 2.5; 4) EPA Region 6 Screening Level Table physical/chemical properties and TPHCWG physical/chemical properties for aliphatic and aromatic hydrocarbon fractions; and 5) state recommended default values for soil properties (fraction of organic carbon (foc), dry soil bulk density (ρ_b), water filled soil porosity (Θ_w), air filled soil porosity (Θ_a), total soil porosity (n), soil particle density (ρ_s) and inverse of the mean concentration at the center of the source (Q/C)) and Summer's default dilution factor as listed below. Where applicable, a risk-based standard was calculated for both carcinogenic and noncarcinogenic health effects and the lower of the two values was selected as the final standard. Screening Standards for constituents not listed in Table 1 and MO-1 RS for constituents not listed in Table 2 shall be developed as described above.

Parameter	State-Recommended Default Value
fraction of organic carbon (foc)	0.006 g/g
dry soil bulk density (ρ_b)	1.7g/cm^3
water filled soil porosity (Θ_w)	0.21 L_{water}/L_{soil}
air filled soil porosity (Θ_a)	0.15 L_{air}/L_{soil}
total soil porosity (n)	0.36 L_{pore}/L_{soil}
soil particle density (ρ_s)	2.65 g/cm^3
dilution factor (DAF)	20
inverse of the mean concentration at the center of the source (Q/C)	79.25 g/m^2-s per kg/m^3 (0.5 acre) (Houston)

Site-specific MO-2 RS and site-specific MO-3 RS shall be based on: 1) toxicity values selected in accordance with the hierarchy defined in Section 2.4; 2) EPA Region 6 Screening Level Table physical/chemical properties; 3) a Target Cancer Risk (TR) and Target Hazard Quotient (THQ) selected in accordance with Section 2.5; 4) site-specific soil properties; DEQ default soil properties; or EPA Region 6 Screening Level Table default soil properties; and 5) the equations presented in this appendix or the most current EPA Region 6 Screening Table equations. Refer to Section A4.0 for definitions of the equation parameters and the default input values. If applicable, a risk-based standard ($Soil_{ssni}$, $Soil_{ssi}$ $Soil_{ni}$, $Soil_{i}$) shall be calculated for both carcinogenic and noncarcinogenic health effects and the lower of the two values shall serve as the standard.

A1.1 Non-industrial (Residential) Risk-Based Standard − (Soil$_{SSni}$, Soil$_{ni}$)

A1.1.1 Carcinogenic Health Effects

Soil$_{SSni}$ or Soil$_{ni}$:

$$SL_{res\text{-}sol\text{-}ca\text{-}tot}\,(mg/kg) = \cfrac{1}{\cfrac{1}{SL_{res\text{-}sol\text{-}ca\text{-}ing}} + \cfrac{1}{SL_{res\text{-}sol\text{-}ca\text{-}der}} + \cfrac{1}{SL_{res\text{-}sol\text{-}ca\text{-}inh}}}$$

incidental ingestion of soil:

$$SL_{res\text{-}sol\text{-}ca\text{-}ing}\,(mg/kg) = \cfrac{TR \times AT_r \left(\dfrac{365\ days}{year} \times LT\ (70\ years)\right)}{CSF_o \left(\dfrac{mg}{Kg\text{-}day}\right)^{-1} \times EF_r \left(\dfrac{350\ days}{year}\right) \times IFS_{adj} \left(\dfrac{114\ mg\text{-}Year}{Kg\text{-}day}\right) \times \left(\dfrac{10^{-6}Kg}{mg}\right)}$$

where:

$$IFS_{adj}\left(\frac{114\ mg\text{-}Year}{Kg\text{-}day}\right) = \cfrac{ED_c\ (6\ years) \times IRS_c \left(\dfrac{200\ mg}{day}\right)}{BW_c\ (15\ Kg)} + \cfrac{ED_r\text{-}ED_c\ (24\ years) \times IRS_a \left(\dfrac{100\ mg}{day}\right)}{BW_a\ (70\ Kg)}$$

inhalation of vapors and particulates emitted from soil:

$$SL_{res\text{-}sol\text{-}ca\text{-}inh} \, (mg/kg) = \frac{TR \times AT_r \left(\dfrac{365 \text{ days}}{\text{year}} \times LT \, (70 \text{ years}) \right)}{IUR \left(\dfrac{\mu g}{m^3} \right)^{-1} \times \left(\dfrac{1000 \, \mu g}{mg} \right) \times EF_r \left(\dfrac{350 \text{ days}}{\text{year}} \right) \times \left(\dfrac{1}{VF_s \left(\dfrac{m^3}{Kg} \right)} + \dfrac{1}{PEF_w \left(\dfrac{m^3}{Kg} \right)} \right) \times ED_r \, (30 \text{ years}) \times ET_{rs} \left(\dfrac{24 \text{ hours}}{\text{day}} \right) \times \left(\dfrac{1 \text{ day}}{24 \text{ hours}} \right)}$$

dermal contact with soil:

$$SL_{res\text{-}sol\text{-}ca\text{-}der} \, (mg/kg) = \frac{TR \times AT_r \left(\dfrac{365 \text{ days}}{\text{year}} \times LT \, (70 \text{ years}) \right)}{\left(\dfrac{CSF_o \left(\dfrac{mg}{Kg\text{-}day} \right)^{-1}}{GIABS} \right) \times EF_r \left(\dfrac{350 \text{ days}}{\text{year}} \right) \times DFS_{adj} \left(\dfrac{361 \text{ mg-Year}}{Kg\text{-}day} \right) \times ABS_d \times \left(\dfrac{10^{-6} Kg}{mg} \right)}$$

where:

$$DFS_{adj} \left(\dfrac{361 \text{ mg-Year}}{Kg\text{-}day} \right) = \frac{ED_c \, (6 \text{ years}) \times SA_c \left(\dfrac{2800 \text{ cm}^2}{\text{day}} \right) \times AF_c \left(\dfrac{0.2 \text{ mg}}{\text{cm}^2} \right)}{BW_c \, (15 \text{ Kg})} + \frac{ED_r - ED_c \, (24 \text{ years}) \times SA_a \left(\dfrac{5700 \text{ cm}^2}{\text{day}} \right) \times AF_a \left(\dfrac{0.07 \text{ mg}}{\text{cm}^2} \right)}{BW_a \, (70 \text{ Kg})}$$

A1.1.2 Mutagenic Health Effects

Soil$_{SSni}$ or Soil$_{ni}$:

$$SL_{res\text{-}sol\text{-}mu\text{-}tot} \ (mg/kg) = \cfrac{1}{\cfrac{1}{SL_{res\text{-}sol\text{-}mu\text{-}ing}} + \cfrac{1}{SL_{res\text{-}sol\text{-}mu\text{-}der}} + \cfrac{1}{SL_{res\text{-}sol\text{-}mu\text{-}inh}}}$$

incidental ingestion of soil:

$$SL_{res\text{-}sol\text{-}mu\text{-}ing} \ (mg/kg) = \cfrac{TR \times AT_r \left(\cfrac{365 \ days}{year} \times LT \ (70 \ years) \right)}{CSF_o \left(\cfrac{mg}{Kg\text{-}day} \right)^{-1} \times EF_r \left(\cfrac{350 \ days}{year} \right) \times IFSM_{adj} \left(\cfrac{489.5 \ mg\text{-}Year}{Kg\text{-}day} \right) \times \left(\cfrac{10^{-6} Kg}{mg} \right)}$$

where:

$$IFSM_{adj\text{-}} \left(\frac{489.5 \ mg\text{-}Year}{Kg\text{-}day} \right) = \cfrac{ED_{0\text{-}2} \ (yr) \times IRS_c \left(\cfrac{200 \ mg}{day} \right) \times 10}{BW_c \ (15 \ Kg)} + \cfrac{ED_{2\text{-}6} \ (yr) \times IRS_c \left(\cfrac{200 \ mg}{day} \right) \times 3}{BW_c \ (15 \ Kg)} +$$

$$\cfrac{ED_{6\text{-}16} \ (yr) \times IRS_a \left(\cfrac{100 \ mg}{day} \right) \times 3}{BW_a \ (70 \ Kg)} + \cfrac{ED_{16\text{-}30} \ (yr) \times IRS_a \left(\cfrac{100 \ mg}{day} \right) \times 1}{BW_a \ (70 \ Kg)}$$

inhalation of vapors and particulates emitted from soil:

$$SL_{res\text{-}sol\text{-}mu\text{-}inh}\,(mg/kg) = \cfrac{TR \times AT_r \left(\cfrac{365\ days}{year} \times LT\,(70\ years) \right)}{\begin{array}{c} EF_r \left(\cfrac{350\ days}{year} \right) \times ET_{rs} \left(\cfrac{24\ hours}{day} \right) \times \left(\cfrac{1\ day}{24\ hours} \right) \times \left(\cfrac{1000\ \mu g}{mg} \right) \times \\[4em] \left(\begin{array}{c} \left(ED_{0\text{-}2}\,(yrs) \times IUR \left({}^{\mu g}\!/_{m^3} \right)^{-1} \times 10 \right) + \left(ED_{2\text{-}6}\,(yrs) \times IUR \left({}^{\mu g}\!/_{m^3} \right)^{-1} \times 3 \right) + \\[2em] \left(ED_{6\text{-}16}\,(yrs) \times IUR \left({}^{\mu g}\!/_{m^3} \right)^{-1} \times 3 \right) + \left(ED_{16\text{-}30}\,(yrs) \times IUR \left({}^{\mu g}\!/_{m^3} \right)^{-1} \times 1 \right) \end{array} \right) \times \left(\cfrac{1}{VF_s \left(\cfrac{m^3}{Kg} \right)} + \cfrac{1}{PEF_w \left(\cfrac{m^3}{Kg} \right)} \right) \end{array}}$$

dermal contact with soil:

$$SL_{res\text{-}sol\text{-}mu\text{-}der}\,(mg/kg) = \cfrac{TR \times AT_r \left(\cfrac{365\ days}{year} \times LT\,(70\ years) \right)}{\left(\cfrac{CSF_o \left(\cfrac{mg}{Kg\text{-}day} \right)^{-1}}{GIABS} \right) \times EF_r \left(\cfrac{350\ days}{year} \right) \times DFSM_{adj} \left(\cfrac{1445\ mg\text{-}Year}{Kg\text{-}day} \right) \times ABS_d \times \left(\cfrac{10^{-6} Kg}{mg} \right)}$$

where:

$$DFSM_{adj} \left(\frac{1445\ mg\text{-}Year}{Kg\text{-}day} \right) = \cfrac{ED_{0\text{-}2}\,(yr) \times AF_c \left(\cfrac{0.2\ mg}{cm^2} \right) \times SA_c \left(\cfrac{2800\ cm^2}{day} \right) \times 10}{BW_c\,(15\ Kg)} + \cfrac{ED_{2\text{-}6}\,(yr) \times AF_c \left(\cfrac{0.2\ mg}{cm^2} \right) \times SA_c \left(\cfrac{2800\ cm^2}{day} \right) \times 3}{BW_c\,(15\ Kg)} +$$

$$\cfrac{ED_{6\text{-}16}\,(yr) \times AF_a \left(\cfrac{0.07\ mg}{cm^2} \right) \times SA_a \left(\cfrac{5700\ cm^2}{day} \right) \times 3}{BW_a\,(70\ Kg)} + \cfrac{ED_{16\text{-}30}\,(yr) \times AF_a \left(\cfrac{0.07\ mg}{cm^2} \right) \times SA_a \left(\cfrac{5700\ cm^2}{day} \right) \times 1}{BW_a\,(70\ Kg)}$$

A1.1.3 Vinyl Chloride Carcinogenic Health Effects

$Soil_{SSni}$ or $Soil_{ni}$:

$$SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}tot} \,(mg/kg) = \cfrac{1}{\cfrac{1}{SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}ing}} + \cfrac{1}{SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}der}} + \cfrac{1}{SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}inh}}}$$

incidental ingestion of soil:

$$SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}ing}\,(mg/kg) = \cfrac{TR}{\left(\cfrac{CSF_o\left(\cfrac{mg}{Kg\text{-}day}\right)^{-1} \times EF_r\left(\cfrac{350\ days}{year}\right) \times IFS_{adj}\left(\cfrac{114\ mg\text{-}yr}{kg\text{-}d}\right) \times \cfrac{10^{-6} Kg}{1\ mg}}{AT_r\left(\cfrac{365\ days}{year} \times LT\,(70\ years)\right)} + \cfrac{CSF_o\left(\cfrac{mg}{Kg\text{-}day}\right)^{-1} \times IRS_c\left(\cfrac{200\ mg}{day}\right) \times \cfrac{10^{-6} Kg}{1\ mg}}{BW_c\,(15\ kg)}\right)}$$

inhalation of vapors and particulates emitted from soil:

$$SL_{res\text{-}soi\text{-}ca\text{-}vc\text{-}inh}\,(mg/kg)=\cfrac{TR}{\left(\cfrac{IUR\left(\mu g/m^3\right)^{-1}\times EF_r\left(\cfrac{350\ days}{year}\right)\times ED\,(30\ years)\times ET_{rs}\left(\cfrac{24\ hours}{day}\right)\times\left(\cfrac{1\ day}{24\ hours}\right)\times\left(\cfrac{1000\ \mu g}{mg}\right)}{AT_r\left(\cfrac{365\ days}{year}\times LT\,(70\ years)\right)\times VF_s\left(\cfrac{m^3}{kg}\right)}+\left(\cfrac{IUR\left(\mu g/m^3\right)^{-1}}{VF_s\left(\cfrac{m^3}{kg}\right)}\times\left(\cfrac{1000\ \mu g}{mg}\right)\right)\right)}$$

dermal contact with soil:

$$SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}der}\,(mg/kg)=\cfrac{TR}{\left(\cfrac{\cfrac{CSF_o\left(\cfrac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\times EF_r\left(\cfrac{350\ days}{year}\right)\times DFS_{adj}\left(\cfrac{361\ mg\text{-}yr}{kg\text{-}day}\right)\times ABS_d\times\cfrac{10^{-6}Kg}{1\ mg}}{AT_r\left(\cfrac{365\ days}{year}\times LT\,(70\ years)\right)}+\left(\cfrac{\cfrac{CSF_o\left(\cfrac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\times SA_c\left(\cfrac{2800\ cm^2}{day}\right)\times AF_c\left(\cfrac{0.2\ mg}{cm^2}\right)\times ABS\times\cfrac{10^{-6}Kg}{1\ mg}}{BW_c\,(15\ kg)}\right)\right)}$$

A1.1.4 Noncarcinogenic Health Effects

Soil$_{SSni}$ or Soil$_{ni}$:

$$SL_{res\text{-}sol\text{-}nc\text{-}tot} \ (mg/kg) = \cfrac{1}{\cfrac{1}{SL_{res\text{-}sol\text{-}nc\text{-}ing}} + \cfrac{1}{SL_{res\text{-}sol\text{-}nc\text{-}der}} + \cfrac{1}{SL_{res\text{-}sol\text{-}nc\text{-}inh}}}$$

incidental ingestion of soil:

$$SL_{res\text{-}sol\text{-}nc\text{-}ing} \ (mg/kg) = \cfrac{THQ \times AT_r \left(\dfrac{365 \ days}{year} \times ED_c \ (6 \ years) \right) \times BW_c \ (15 \ Kg)}{EF_r \left(\dfrac{350 \ days}{year} \right) \times ED_c \ (6 \ year) \times \cfrac{1}{RfD_o \left(\dfrac{mg}{Kg\text{-}day} \right)} \times IRS_c \left(\dfrac{200 \ mg}{day} \right) \times \dfrac{10^{-6} Kg}{1 mg}}$$

inhalation of vapors and particulates emitted from soil:

$$SL_{res\text{-}sol\text{-}nc\text{-}inh}\ (mg/kg) = \frac{THQ \times AT_r \left(\dfrac{365\ days}{year} \times ED_c\ (6\ years) \right)}{EF_r \left(\dfrac{350\ days}{year} \right) \times ED_c\ (6\ year) \times ET_{rs} \left(\dfrac{24\ hours}{day} \right) \times \left(\dfrac{1\ day}{24\ hours} \right) \times \dfrac{1}{RfC \left(\dfrac{mg}{m^3} \right)} \times \left(\dfrac{1}{VF_s \left(\dfrac{m^3}{Kg} \right)} + \dfrac{1}{PEF_w \left(\dfrac{m^3}{Kg} \right)} \right)}$$

dermal contact with soil:

$$SL_{res\text{-}sol\text{-}nc\text{-}der}\ (mg/kg) = \frac{THQ \times AT_r \left(\dfrac{365\ days}{year} \times ED_c\ (6\ years) \right) \times BW_c\ (15\ Kg)}{EF_r \left(\dfrac{350\ days}{year} \right) \times ED_c\ (6\ year) \times \dfrac{1}{\left(RfD_o \left(\dfrac{mg}{Kg\text{-}day} \right) \times GIABS \right)} \times SA_c \left(\dfrac{2800\ cm^2}{day} \right) \times AF_c \left(\dfrac{0.2\ mg}{cm^2} \right) \times ABS_d \times \dfrac{10^{-6} Kg}{1 mg}}$$

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A1.2 Industrial/Commercial (Composite Worker) Risk-Based Standard – (Soil$_{SSi}$, Soil$_i$)

A1.2.1 Carcinogenic Health Effects

Soil$_{SSi}$ or Soil$_i$:

$$SL_{w\text{-sol-ca-tot}} \, (mg/kg) = \cfrac{1}{\cfrac{1}{SL_{w\text{-sol-ca-ing}}} + \cfrac{1}{SL_{w\text{-sol-ca-der}}} + \cfrac{1}{SL_{w\text{-sol-ca-inh}}}}$$

incidental ingestion of soil:

$$SL_{w\text{-sol-ca-ing}} \, (mg/kg) = \cfrac{TR \times AT_{ow}\left(\cfrac{365 \ days}{year} \times LT \ (70 \ years)\right) \times BW_{ow} \ (70 \ Kg)}{EF_{iw}\left(250 \ \cfrac{days}{year}\right) \times ED_{ow} \ (25 \ years) \times CSF_{o}\left(\cfrac{mg}{kg\text{-}day}\right)^{-1} \times IR_{ow}\left(100 \ \cfrac{mg}{day}\right) \times \left(\cfrac{10^{-6} \ Kg}{1 \ mg}\right)}$$

inhalation of vapors and particulates emitted from soil:

$$SL_{w\text{-sol-ca-inh}} \, (mg/kg) = \cfrac{TR \times AT_{ow}\left(\cfrac{365 \ days}{year} \times LT \ (70 \ years)\right)}{EF_{iw}\left(250 \ \cfrac{days}{year}\right) \times ED_{ow} \ (25 \ years) \times ET_{ws}\left(\cfrac{8 \ hours}{day}\right) \times \left(\cfrac{1 \ day}{24 \ hours}\right) \times IUR\left(\mu g\Big/m^3\right)^{-1} \times \left(\cfrac{1000 \ \mu g}{mg}\right) \times \left(\cfrac{1}{VF_s\left(\cfrac{m^3}{kg}\right)} + \cfrac{1}{PEF_w\left(\cfrac{m^3}{kg}\right)}\right)}$$

dermal exposure:

$$SL_{w\text{-sol-ca-der}}\ (mg/kg) = \frac{TR \times AT_{ow}\left(\frac{365\ days}{year} \times LT\ (70\ years)\right) \times BW_{ow}\ (70\ Kg)}{EF_{iw}\left(250\ \frac{days}{year}\right) \times ED_{ow}\ (25\ years) \times \left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right) \times SA_{ow}\left(\frac{3300\ cm^2}{day}\right) \times AF_{ow}\left(\frac{0.2\ mg}{cm^2}\right) \times ABS_d \times \left(\frac{10^{-6}\ Kg}{1\ mg}\right)}$$

A1.2.2 Noncarcinogenic Health Effects

Soil$_{SSi}$ or Soil$_i$:

$$SL_{w\text{-sol-nc-tot}}\ (mg/kg) = \frac{1}{\dfrac{1}{SL_{w\text{-sol-nc-ing}}} + \dfrac{1}{SL_{w\text{-sol-nc-der}}} + \dfrac{1}{SL_{w\text{-sol-nc-inh}}}}$$

incidental ingestion of soil:

$$SL_{w\text{-sol-nc-ing}}\ (mg/kg) = \frac{THQ \times AT_{ow}\left(\frac{365\ days}{year} \times ED_{ow}\ (25\ years)\right) \times BW_{ow}\ (70\ Kg)}{EF_{iw}\left(250\ \frac{days}{year}\right) \times ED_{ow}\ (25\ years) \times \dfrac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)} \times IR_{ow}\left(100\ \frac{mg}{day}\right) \times \left(\frac{10^{-6}\ Kg}{1\ mg}\right)}$$

<u>inhalation of vapors and particulates emitted from soil</u>:

$$SL_{w\text{-}sol\text{-}nc\text{-}inh}\ (mg/kg) = \frac{THQ \times AT_{ow} \left(\frac{365\ days}{year} \times ED_{ow}\ (25\ years) \right)}{EF_{iw} \left(250\ \frac{days}{year} \right) \times ED_{ow}\ (25\ years) \times ET_{ws} \left(\frac{8\ hours}{day} \right) \times \left(\frac{1\ day}{24\ hours} \right) \times \frac{1}{RfC \left(mg/m^3 \right)} \times \left(\frac{1}{VF_s \left(\frac{m^3}{kg} \right)} + \frac{1}{PEF_w \left(\frac{m^3}{kg} \right)} \right)}$$

<u>dermal exposure</u>:

$$SL_{w\text{-}sol\text{-}nc\text{-}der}\ (mg/kg) = \frac{THQ \times AT_{ow} \left(\frac{365\ days}{year} \times ED_{ow}\ (25\ years) \right) \times BW_{ow}\ (70\ Kg)}{EF_{iw} \left(250\ \frac{days}{year} \right) \times ED_{ow}\ (25\ years) \times \left(\frac{1}{RfD_o \left(\frac{mg}{kg\text{-}day} \right) \times GIABS} \right) \times SA_{ow} \left(\frac{3300\ cm^2}{day} \right) \times AF_{ow} \left(\frac{0.2\ mg}{cm^2} \right) \times ABS_d \times \left(\frac{10^{-6}\ Kg}{1\ mg} \right)}$$

A1.3 Volatilization Factor (VF) for Soil$_{ssni}$, Soil$_{ni}$, Soil$_{ssi}$, Soil$_i$

The soil-to-air VF is used to define the relationship between the concentration of the constituent in soil and the flux of the volatilized constituent to air. VF is only calculated for volatile organic compounds (VOCs). VOCs generally are chemicals with a Henry's Law constant greater than or equal to 1×10^{-5} atm-m^3/mole and a molecular weight of less than 200 g/mole. Exceptions are: Mercury (elemental), Pyrene, Dibromochloromethane and Dibromo-3-chloropropane, 1,2-.

The basic principle of the model is applicable only if the soil constituent concentration is at or below saturation. Saturation is the soil constituent concentration (Soil$_{sat}$) at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above saturation, pure liquid-phase constituent may be present in the soil. Soil$_{sat}$ concentrations represent an upper limit to the applicability of the VF model because a basic principle of the model (Henry's Law) does not apply where constituents are present in free phrase. Therefore, above saturation, the risk-based soil RS based on the VF model cannot be accurately calculated based on volatilization. Because of this limitation, the risk-based RS calculated using the VF must be compared with the Soil$_{sat}$. If the Soil$_{ssni}$, Soil$_{ni}$, Soil$_{ssi}$, or Soil$_i$ is greater than Soil$_{sat}$, then the risk-based RS is set equal to Soil$_{sat}$. Soil$_{sat}$ should be calculated using the same soil characteristics (bulk density, average water content, organic carbon content, etc.) used to calculate VF (*Soil Screening Guidance*, EPA 1996).

Volatilization Factor:

$$VF = \frac{\frac{Q}{C_w} \times \left(3.14 \times D_A \times T\right)^{\frac{1}{2}} \times 10^{-4} \left(m^2/cm^2\right)}{2 \times \rho_b \times D_A}$$

where

$$\frac{Q}{C_w} = A \times \exp\left[\frac{\left(\ln A_s - B\right)^2}{C}\right] \quad \text{and}$$

$$D_A = \frac{\left[\left(\theta_a^{10/3} \times D_{ia} \times H' + \theta_w^{10/3} \times D_{iw}\right)/n^2\right]}{\rho_b \times K_d + \theta_w + \theta_a \times H'}$$

Diffusivity in water:

$$D_{iw}\left(\frac{cm^2}{s}\right) = 0.0001518 \times \left(\frac{T\,^0C + 273.16}{298.16}\right) \times \left(\frac{MW\left(\frac{g}{mol}\right)}{\rho\left(\frac{g}{cm^3}\right)}\right)^{-0.6}$$

where

T typically = $25\,^0C$

If density is not available,

$$D_{iw}\left(\frac{cm^2}{s}\right) = 0.000222 \times (MW)^{-\left(\frac{2}{3}\right)}$$

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<u>Diffusivity in air</u>:

$$D_{ia}\left(\frac{cm^2}{s}\right) = \frac{0.00229 \times \left(T\,^{0}C + 273.16\right)^{1.5} \times \sqrt{0.034 + \left(\dfrac{1}{MW\left(\dfrac{g}{mol}\right)}\right)} \times MW_{cor}}{\left(\left(\dfrac{MW\left(\dfrac{g}{mol}\right)}{2.5 \times \rho\left(\dfrac{g}{cm^3}\right)}\right)^{0.333} + 1.8\right)^2}$$

where

T typically $= 25\,^{0}C$

$MW_{cor} = \left(1 - 0.000015 \times MW^2\right)$ If MW_{cor} is less than 0.4, then MW_{cor} is set to 0.4.

If density is not available,

$$D_{ia}\left(\frac{cm^2}{s}\right) = 1.9 \times \left(MW\left(\frac{g}{mol}\right)^{-\left(\frac{2}{3}\right)}\right) \quad \text{except for dioxins use,} \quad D_{ia}\left(\frac{cm^2}{s}\right) = \left(\frac{154}{MW\left(\frac{g}{mol}\right)}\right)^{0.5} \times 0.068$$

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A1.4 Particulate Emission Factor (PEF) for $Soil_{ssni}$, $Soil_{ni}$, $Soil_{ssi}$, $Soil_i$

$$PEF_w = \frac{Q}{C_w} \times \frac{3,600}{0.036 \times (1-V) \times \left(U_m/U_t\right)^3 \times F(x)}$$

where

$$\frac{Q}{C_w} = A \times \exp\left[\frac{\left(\ln A_s - B\right)^2}{C}\right]$$

A1.5 Soil to Groundwater Pathway (Soil$_{SSGW}$, Soil$_{GW1}$, Soil$_{GW2}$, Soil$_{GW3}$)

A1.5.1 Method 1 Partitioning Equation

The soil/water partition equation given below shall be used to relate the constituent concentration adsorbed to the soil organic carbon to the soil leachate concentration in the zone of contamination.

The GW$_1$ shall serve as the C$_w$ for Soil$_{GW1}$ and Soil$_{GW2}$. The GW$_{3NDW}$ or GW$_{3DW}$ shall serve as the C$_w$ for Soil$_{GW3NDW}$ and Soil$_{GW3DW}$, respectively. Refer to Table 3 for the GW$_1$, GW$_2$, GW$_{3NDW}$, GW$_{3DW}$.   For constituents not listed in Table 3, the MCL shall serve as the GW$_1$. If an MCL is not available, then a risk-based GW$_1$ shall be calculated.

A Summers dilution factor (DAF) shall be used to yield the maximum theoretical constituent concentration in soil that is protective of the appropriate groundwater use. As chemicals present in the soil migrate, their concentrations are reduced by physical, chemical, and biochemical processes. To account for these processes, a dilution factor is used in the estimation of a soil concentration that is protective of groundwater. Under the SO and MO-1, a default Summers DAF of 20 shall be used for the calculation of the Soil$_{GW}$. A DAF of 20 is considered protective of groundwater resources for soil sources up to 0.5 acre in size (*Soil Screening Guidance: Technical Background Document*, EPA 1996). A site-specific Summers DAF may be used under MO-2 and MO-3.

$$SSL(mg/kg) = C_w\left(\frac{mg}{L}\right) \times DAF \times \left[K_d\left(\frac{L}{kg}\right) + \left(\frac{\left(\theta_w\left(\frac{L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'\right)}{\rho_b\left(\frac{1.5\ kg}{L}\right)}\right)\right]$$

where:

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{water}}{L_{soil}}\right) - \theta_w\left(\frac{0.3\ L_{water}}{L_{soil}}\right)\ ;$$

$$n\left(\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\frac{\rho_b\left(\frac{1.5\ kg}{L}\right)}{\rho_s\left(\frac{2.65\ kg}{L}\right)}\right)\ and$$

$$K_d\left(\frac{L}{kg}\right) = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}\ (0.002\ unitless)$$

A1.5.2 Method 2 Leachate Test

A leach test may be used instead of the soil/water partition equation to relate concentrations of constituents adsorbed to soil organic carbon to soil leachate concentrations in the impacted zone. The EPA Synthetic Precipitation Leaching Procedure (SPLP, EPA SW-846 Method 1312, U.S. EPA, 1994d) is the recommended leach test for evaluation of the soil to groundwater pathway. The SPLP was developed to model an acid rain leaching environment and is generally appropriate for an impacted soil scenario (*Soil Screening Guidance,* EPA 1996). The SPLP may not be appropriate for all situations thus alternative leach tests may be approved on a site-specific basis.

A1.6   Soil Saturation (Soil$_{sat}$)

The soil saturation concentration corresponds to the constituent concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil pore air have been reached. Above this concentration, the soil constituent may be present in free phase (i.e., nonaqueous phase liquids (NAPLs) for constituents that are liquid at ambient soil temperatures and pure solid phases for compounds that are solid at ambient soil temperatures). Soil$_{sat}$ is not calculated for chemicals that are solid at ambient soil temperatures. The Soil$_{sat}$ RS for the petroleum fractions were obtained from the literature, refer to Appendix D for additional information on addressing Soil$_{sat}$ levels for petroleum hydrocarbons.

$$C_{sat} = \frac{S \left(\frac{mg}{L}\right)}{\rho_b \left(\frac{Kg}{L}\right)} \times \left(K_d \left(\frac{L}{Kg}\right) \times \rho_b \left(\frac{Kg}{L}\right) + \theta_w \left(\frac{L_{water}}{L_{soil}}\right) + H' \times \theta_a \left(\frac{L_{air}}{L_{soil}}\right) \right)$$

where

$$Kd = K_{oc} \left(\frac{L}{Kg}\right) \times f_{oc} \left(\frac{g}{g}\right),$$

$$\theta_a \left(\frac{L_{air}}{L_{soil}}\right) = n \left(\frac{L_{pore}}{L_{soil}}\right) - \theta_w \left(\frac{L_{water}}{L_{soil}}\right) \text{ and}$$

$$n = 1 - \left(\frac{\rho_b \left(\frac{Kg}{L}\right)}{\rho_s \left(\frac{Kg}{L}\right)} \right)$$

A2.0 Groundwater Standards

The Groundwater Standards include GW_{SS}, GW_1, GW_2, GW_{3DW}, GW_{3NDW}, $Water_{sol}$. The groundwater Screening Standards and RECAP Standards shall be identified or calculated in accordance with this appendix. Site-specific input values shall not be used in the calculation of GW_{ss}, GW_1, GW_2, or GW_3 Standards.

A2.1 Groundwater Classifications 1 and 2 (GW_{SS}, GW_1, GW_2)

The Screening Option GW_{ss} (Table 1), Management Option 1 GW_1 and GW_2 RECAP Standards (Tables 3), and the Appendix H MO-2 GW_1 and GW_2 RECAP Standards are based on the SDWA MCL; in the absence of an MCL, a risk-based value was calculated using: 1) the equations presented in this appendix; 2) toxicity values selected in accordance with the hierarchy defined in Section 2.4; 3) a Target Cancer Risk (TR) and Target Hazard Quotient (THQ) as specified in Section 2.5; 4) EPA Region 6 Screening Level Table physical/chemical properties and TPHCWG physical/chemical properties for aliphatic and aromatic hydrocarbon fractions; and 5) if applicable, a risk-based standard (GW_1 and GW_2) was calculated for both carcinogenic and noncarcinogenic health effects and the lower of the two values was selected as the standard. For a COC not listed in Tables 1 and 3, a GW_{ss}, GW_1, and/or GW_2 shall be developed in accordance with this appendix. Refer to Section A4.0 for definitions of the equation parameters and the default input values.

A2.1.1 Carcinogenic Health Effects

GW_1 or GW_2:

$$SL_{water\text{-}ca\text{-}tot}\ (\mu g/L) = \cfrac{1}{\cfrac{1}{SL_{water\text{-}ca\text{-}ing}} + \cfrac{1}{SL_{water\text{-}ca\text{-}der}} + \cfrac{1}{SL_{water\text{-}ca\text{-}inh}}}$$

ingestion of water:

$$SL_{water-ca-ing} \, (\mu g/L) = \dfrac{TR \times AT_r \left(\dfrac{365 \, days}{year} \times LT \, (70 \, years) \right) \times \left(\dfrac{1000 \, \mu g}{mg} \right)}{EF_r \left(\dfrac{350 \, days}{year} \right) \times CSF_o \left(\dfrac{mg}{kg\text{-}day} \right)^{-1} \times \left(IFW_{adj} \left(\dfrac{1.086 \, L\text{-}Year}{Kg\text{-}day} \right) \right)}$$

where:

$$IFW_{adj} \left(\dfrac{1.086 \, L\text{-}Year}{Kg\text{-}day} \right) = \dfrac{ED_c \, (6 \, years) \times IRW_c \left(\dfrac{1 \, L}{day} \right)}{BW_c \, (15 \, Kg)} + \dfrac{ED_r\text{-}ED_c \, (24 \, years) \times IRW_a \left(\dfrac{2 \, L}{day} \right)}{BW_a \, (70 \, Kg)}$$

inhalation of volatiles:

$$SL_{water-ca-inh} \, (\mu g/L) = \dfrac{TR \times AT_r \left(\dfrac{365 \, days}{year} \times LT \, (70 \, years) \right)}{EF_r \left(\dfrac{350 \, days}{year} \right) \times ED_r \, (30 \, years) \times ET_{rw} \left(\dfrac{24 \, hours}{day} \right) \times \left(\dfrac{1 \, day}{24 \, hours} \right) \times IUR \left(\mu g / m^3 \right)^{-1} \times K \left(\dfrac{0.5 \, L}{m^3} \right)}$$

<u>dermal exposure to water</u>:

FOR INORGANICS:

$$SL_{water-ca-der}(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2-event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{K_p\left(\frac{cm}{hr}\right) \times ET_{rw-adj}\left(\frac{0.664\ hours}{event}\right)}$$

FOR ORGANICS:

$$IF\ ET_{rw-adj}\left(\frac{hours}{event}\right) \le t^*\ (hr), then\ SL_{water-ca-der}(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2-event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\frac{cm}{hr}\right)\sqrt{\frac{6 \times \tau_{event}\left(\frac{hours}{event}\right) \times ET_{rw-adj}\left(\frac{0.664\ hours}{event}\right)}{\pi}}}$$

or,

$$IF\ ET_{rw-adj}\left(\frac{hours}{event}\right) > t^*\ (hr), then\ SL_{water-ca-der}(\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2-event}\right) \times \left(\frac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hr}\right) \times \left[\frac{ET_{rw-adj}\left(\frac{0.664\ hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\frac{hours}{event}\right) \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2-event}\right) = \frac{TR \times AT_r\left(\frac{365\ days}{year} \times LT\ (70\ years)\right) \times \left(\frac{1000\ \mu g}{mg}\right)}{\left(\frac{CSF_o\left(\frac{mg}{Kg-day}\right)^{-1}}{GIABS}\right) \times EF_r\left(\frac{350\ days}{year}\right) \times DFW_{adj}\left(\frac{8811.4\ cm^2-event-day}{kg}\right)}$$

where:

$$DFW_{adj}\left(\frac{8811.4\ cm^2-event-day}{kg}\right) = \frac{EV_c\left(\frac{1\ events}{day}\right) \times ED_c\ (6\ years) \times SA_c\left(6,600\ cm^2\right)}{BW_c\ (15\ Kg)} + \frac{EV_a\left(\frac{1\ events}{day}\right) \times ED_a\ (24\ years) \times SA_a\left(18,000\ cm^2\right)}{BW_a\ (70\ Kg)}$$

and:

$$ET_{rw-adj}\left(\frac{0.664\ hours}{event}\right) = \frac{\left(ET_{rwc}\left(\frac{1\ hours}{event}\right) \times ED_c\ (6\ years) + ET_{rwa}\left(\frac{0.58\ hours}{event}\right) \times ED_r - ED_c\ (24\ years)\right)}{ED_r\ (30\ years)}$$

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A2.1.2 Mutagenic Health Effects

GW$_1$ or GW$_2$:

$$SL_{water-mu-tot}\ (\mu g/L) = \cfrac{1}{\cfrac{1}{SL_{water-mu-ing}} + \cfrac{1}{SL_{water-mu-der}} + \cfrac{1}{SL_{water-mu-inh}}}$$

ingestion of water:

$$SL_{water-mu-ing}\ (\mu g/L) = \cfrac{TR \times AT_r \left(\cfrac{365\ days}{year} \times LT\ (70\ years)\right) \times \left(\cfrac{1000\ \mu g}{mg}\right)}{CSF_o \left(\cfrac{mg}{Kg\text{-}day}\right)^{-1} \times EF_r \left(\cfrac{350\ days}{year}\right) \times IFWM_{adj} \left(\cfrac{3.39\ L\text{-}Year}{Kg\text{-}day}\right)}$$

where:

$$IFWM_{adj\text{-}} \left(\cfrac{3.39\ L\text{-}Year}{Kg\text{-}day}\right) = \cfrac{ED_{0\text{-}2}\ (yr) \times IRW_c \left(\cfrac{1\ L}{day}\right) \times 10}{BW_c\ (15\ Kg)} + \cfrac{ED_{2\text{-}6}\ (yr) \times IRW_c \left(\cfrac{1\ L}{day}\right) \times 3}{BW_c\ (15\ Kg)} +$$

$$\cfrac{ED_{6\text{-}16}\ (yr) \times IRW_a \left(\cfrac{2\ L}{day}\right) \times 3}{BW_a\ (70\ Kg)} + \cfrac{ED_{16\text{-}30}\ (yr) \times IRW_a \left(\cfrac{2\ L}{day}\right) \times 1}{BW_a\ (70\ Kg)}$$

<u>dermal exposure to water</u>:

FOR INORGANICS:

$$SL_{water\text{-}mu\text{-}der} (\mu g/L) = \dfrac{DA_{event}\left(\dfrac{ug}{cm^2\text{-}event}\right) \times \left(\dfrac{1000\ cm^3}{L}\right)}{K_p\left(\dfrac{cm}{hr}\right) \times ET_{rw\text{-}madj}\left(\dfrac{0.664\ hours}{event}\right)}$$

FOR ORGANICS:

$$IF\ ET_{rw\text{-}madj}\left(\dfrac{0.664\ hours}{event}\right) \leq t^*\ (hr), then\ SL_{water\text{-}mu\text{-}der}(\mu g/L) = \dfrac{DA_{event}\left(\dfrac{ug}{cm^2\text{-}event}\right) \times \left(\dfrac{1000\ cm^3}{L}\right)}{2 \times FA \times K_p\left(\dfrac{cm}{hr}\right)\sqrt{\dfrac{6 \times \tau_{event}\left(\dfrac{hours}{event}\right) \times ET_{rw\text{-}madj}\left(\dfrac{hours}{event}\right)}{\pi}}}$$

or,

$$IF\ ET_{rw\text{-}madj}\left(\dfrac{0.664\ hours}{event}\right) > t^*\ (hr), then\ SL_{water\text{-}mu\text{-}der}(\mu g/L) = \dfrac{DA_{event}\left(\dfrac{ug}{cm^2\text{-}event}\right) \times \left(\dfrac{1000\ cm^3}{L}\right)}{FA \times K_p\left(\dfrac{cm}{hr}\right) \times \left[\dfrac{ET_{rdw\text{-}madj}\left(\dfrac{hours}{event}\right)}{1+B} + 2 \times \tau_{event}\left(\dfrac{hours}{event}\right) \times \left(\dfrac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\dfrac{ug}{cm^2\text{-}event}\right) = \dfrac{TR \times AT_r\left(\dfrac{365\ days}{year} \times LT\ (70\ years)\right) \times \left(\dfrac{1000\ \mu g}{mg}\right)}{\left(\dfrac{CSF_o\left(\dfrac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\right) \times DFWM_{adj}\left(\dfrac{25394.29\ events\text{-}cm^2}{kg}\right) \times EF_r\left(\dfrac{350\ days}{year}\right)}$$

where:

$$DFWM_{adj}\left(\dfrac{25394.29\ events\text{-}cm^2}{kg}\right) = \left[\left(\dfrac{EV_{0\text{-}2}\left(\dfrac{1\ events}{day}\right) \times ED_{0\text{-}2}\ (years) \times SA_c\left(6{,}600\ cm^2\right) \times 10}{BW_c\ (15\ Kg)}\right) + \left(\dfrac{EV_{2\text{-}6}\left(\dfrac{1\ events}{day}\right) \times ED_{2\text{-}6}\ (years) \times SA_c\left(6{,}600\ cm^2\right) \times 3}{BW_c\ (15\ Kg)}\right) + \left(\dfrac{EV_{6\text{-}16}\left(\dfrac{1\ events}{day}\right) \times ED_{6\text{-}16}\ (years) \times SA_a\left(18{,}000\ cm^2\right) \times 3}{BW_a\ (70\ Kg)}\right) + \left(\dfrac{EV_{16\text{-}30}\left(\dfrac{1\ events}{day}\right) \times ED_{16\text{-}30}\ (years) \times SA_a\left(18{,}000\ cm^2\right) \times 1}{BW_a\ (70\ Kg)}\right)\right]$$

and:

$$ET_{rw\text{-}madj}\left(\dfrac{0.664\ hours}{event}\right) = \dfrac{\left(\begin{array}{l}ET_{0\text{-}2}\left(\dfrac{1\ hours}{event}\right) \times ED_{0\text{-}2}\ (years) + ET_{2\text{-}6}\left(\dfrac{1\ hours}{event}\right) \times ED_{2\text{-}6}\ (years) + \\ ET_{6\text{-}16}\left(\dfrac{0.58\ hours}{event}\right) \times ED_{6\text{-}16}\ (years) + ET_{16\text{-}30}\left(\dfrac{0.58\ hours}{event}\right) \times ED_{16\text{-}30}\ (years)\end{array}\right)}{ED_{0\text{-}2}\ (years) + ED_{2\text{-}6}\ (years) + ED_{6\text{-}16}\ (years) + ED_{16\text{-}30}\ (years)}$$

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inhalation of volatiles:

$$SL_{water\text{-}mu\text{-}inh} \, (\mu g/L) = \cfrac{TR \times AT_r \left(\cfrac{365 \ days}{year} \times LT \ (70 \ years) \right)}{EF_r \left(\cfrac{350 \ days}{year} \right) \times K \left(\cfrac{0.5 \ L}{m^3} \right) \times ET_{rw} \left(\cfrac{24 \ hours}{day} \right) \times \left(\cfrac{1 \ day}{24 \ hours} \right) \times \left(\begin{array}{l} \left(ED_{0\text{-}2} \ (yrs) \times IUR \left(\mu g \big/ m^3 \right)^{-1} \times 10 \right) + \left(ED_{2\text{-}6} \ (yrs) \times IUR \left(\mu g \big/ m^3 \right)^{-1} \times 3 \right) + \\ \left(ED_{6\text{-}16} \ (yrs) \times IUR \left(\mu g \big/ m^3 \right)^{-1} \times 3 \right) + \left(ED_{16\text{-}30} \ (yrs) \times IUR \left(\mu g \big/ m^3 \right)^{-1} \times 1 \right) \end{array} \right)}$$

A2.1.3 Vinyl Chloride Carcinogenic Health Effects

GW$_1$ or GW2:

$$SL_{water\text{-}ca\text{-}vc\text{-}tot} \, (\mu g/L) = \cfrac{1}{\cfrac{1}{SL_{water\text{-}ca\text{-}vc\text{-}ing}} + \cfrac{1}{SL_{water\text{-}ca\text{-}vc\text{-}der}} + \cfrac{1}{SL_{water\text{-}ca\text{-}vc\text{-}inh}}}$$

ingestion of water:

$$SL_{res\text{-}water\text{-}ca\text{-}vc\text{-}ing}(\mu g/L) = \dfrac{TR}{\left(\dfrac{CSF_o\left(\dfrac{mg}{Kg\text{-}day}\right)^{-1} \times EF_r\left(\dfrac{350\ days}{year}\right) \times IFW_{adj}\left(\dfrac{1.086\ L\text{-}yr}{kg\text{-}day}\right) \times \left(\dfrac{mg}{1000\ \mu g}\right)}{AT\left(\dfrac{365\ days}{year} \times LT\ (70\ years)\right)}\right) + \left(\dfrac{CSF_o\left(\dfrac{mg}{Kg\text{-}day}\right)^{-1} \times IRW_c\left(\dfrac{1\ L}{day}\right) \times \left(\dfrac{mg}{1000\ \mu g}\right)}{BW_c\ (15\ kg)}\right)}$$

where:

$$IFW_{adj}\left(\dfrac{1.086\ L\text{-}Year}{Kg\text{-}day}\right) = \dfrac{ED_c\ (6\ years) \times IRW_c\left(\dfrac{1\ L}{day}\right)}{BW_c\ (15\ Kg)} + \dfrac{ED_r\text{-}ED_c\ (24\ years) \times IRW_a\left(\dfrac{2\ L}{day}\right)}{BW_a\ (70\ Kg)}$$

inhalation of volatiles:

$$SL_{res\text{-}water\text{-}ca\text{-}vc\text{-}inh}(\mu g/L) = \dfrac{TR}{\left(\dfrac{IUR\left(\mu g\big/m^3\right)^{-1} \times EF\left(\dfrac{350\ days}{year}\right) \times ED\ (30\ years) \times ET_{rw}\left(\dfrac{24\ hours}{day}\right) \times \left(\dfrac{1\ day}{24\ hours}\right) \times K\left(\dfrac{0.5\ L}{m^3}\right)}{AT\left(\dfrac{365\ days}{year} \times LT\ (70\ years)\right)}\right) + \left(IUR\left(\mu g\big/m^3\right)^{-1} \times K\left(\dfrac{0.5\ L}{m^3}\right)\right)}$$

<u>dermal exposure to water</u>:

$$\text{IF } ET_{rw\text{-}adj}\left(\frac{0.664 \text{ hours}}{\text{event}}\right) \le t^{*} \text{ (hr)}, \text{then } SL_{water\text{-}vc\text{-}der}\ (\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right)\times\left(\frac{1000 \text{ cm}^3}{L}\right)}{2\times FA \times K_p\left(\frac{cm}{hr}\right)\sqrt{\dfrac{6\times\tau_{event}\left(\frac{hours}{event}\right)\times ET_{rw\text{-}adj}\left(\frac{0.664 \text{ hours}}{\text{event}}\right)}{\pi}}}$$

or,

$$\text{IF } ET_{rw\text{-}adj}\left(\frac{0.664 \text{ hours}}{\text{event}}\right) > t^{*} \text{ (hr)}, \text{then } SL_{water\text{-}vc\text{-}der}\ (\mu g/L) = \frac{DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right)\times\left(\frac{1000 \text{ cm}^3}{L}\right)}{FA \times K_p\left(\frac{cm}{hr}\right)\times\left[\dfrac{ET_{rw\text{-}adj}\left(\frac{0.664 \text{ hours}}{\text{event}}\right)}{1+B}+2\times\tau_{event}\left(\frac{hours}{event}\right)\times\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

where:

$$DA_{event}\left(\frac{ug}{cm^2\text{-}event}\right) = \frac{TR}{\left(\dfrac{\dfrac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\times EF_r\left(\frac{350 \text{ days}}{\text{year}}\right)\times DFW_{adj}\left(\frac{8811.4 \text{ cm}^2\text{-events}}{kg}\right)}{AT_r\left(\frac{365 \text{ days}}{\text{year}}\times LT\,(70 \text{ years})\right)\times\left(\frac{1000\ \mu g}{mg}\right)}\right)+\left(\dfrac{\dfrac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\times EV_{rdwc}\left(\frac{1 \text{ events}}{\text{day}}\right)\times SA_c\left(6,600 \text{ cm}^2\right)}{BW_c\,(15 \text{ Kg})\times\left(\frac{1000\ \mu g}{mg}\right)}\right)}$$

where:

$$DFW_{adj}\left(\frac{8811.4 \text{ cm}^2\text{-event}}{kg}\right) = \frac{EV_c\left(\frac{1 \text{ events}}{\text{day}}\right)\times ED_c\,(6 \text{ years})\times SA_c\left(6,600 \text{ cm}^2\right)}{BW_c\,(15 \text{ Kg})} + \frac{EV_a\left(\frac{1 \text{ events}}{\text{day}}\right)\times ED_a\,(24 \text{ years})\times SA_a\left(18,000 \text{ cm}^2\right)}{BW_a\,(70 \text{ Kg})}$$

and:

$$ET_{rw\text{-}adj}\left(\frac{0.664 \text{ hours}}{\text{event}}\right) = \frac{\left(ET_{rwc}\left(\frac{1 \text{ hours}}{\text{event}}\right)\times ED_c\,(6 \text{ years})\right)+\left(ET_{rwa}\left(\frac{0.58 \text{ hours}}{\text{event}}\right)\times ED_r - ED_c\,(24 \text{ years})\right)}{ED_r\,(30 \text{ years})}$$

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A2.2 Groundwater Classification 3

The GW$_{3NDW}$ and GW$_{3DW}$ shall be obtained from Table 3. For the generation of Table 3, the procedures described below were used for the identification or calculation of the GW RS. If a constituent is not listed in Table 3, a GW$_{3NDW}$ or GW$_{3DW}$ shall be identified or calculated based on the procedures presented below. The risk-based criteria shall be based on: 1) the equations presented in this appendix; 2) toxicity values selected in accordance with the hierarchy defined in Section 2.4; 3) a target cancer risk and target hazard quotient as specified in Section 2.5; and 4) EPA Region 6 Screening Level Table physical/chemical properties and TPHCWG physical/chemical properties for aliphatic and aromatic hydrocarbon fractions. Note: No substitutions shall be made for the input values presented below for the calculation of the GW$_{3NDW}$.

A2.2.1 GW$_{3NDW}$

Protection of Surface Water Classified as a Non-Drinking Water Supply

The State human health protection non-drinking water supply criterion in LAC 33:IX.1113, Table 1 shall be used as the GW$_{3NDW}$. If a State human health protection non-drinking water supply criterion is not available, then the highest of the following three values shall serve as the GW$_{3NDW}$: 1) a risk-based criterion calculated as presented below; if applicable criteria shall be calculated for both carcinogenic health effects and noncarcinogenic health effects and the lower of the two values shall be selected as the risk-based criterion; 2) the MCL; and (3) the State human health protection drinking water supply criterion. Note: No substitutions shall be made for the input values presented below for the calculation of the GW$_{3NDW}$.

A2.2.1.1 Carcinogenic Health Effects

$$GW_{3NDW} \text{ (mg/l)} = \frac{TR \times BW_a}{SF_o[IRW_{NDW} + (BCF \times IRF)]}$$

where:

Parameter	Definition (units)	Input Value
GW$_{3NDW}$	risk-based constituent concentration in water (mg/l)	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]
BW$_a$	average adult body weight (kg)	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]
SF$_o$	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [c]
IRW$_{NDW}$	incidental water ingestion rate (L/day)	0.089 [a,d]
BCF	bioconcentration factor (L/kg)	CS [c,e]

[a]*Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana,* Water Permits Division Office of Environmental Services, LDEQ 2004.

[b]An fish ingestion rate of 0.02 kg/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, a fish ingestion rate of 0.0065 kg/day shall be used.

[c]Chemical-specific

[d]An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, an incidential water ingestion rate of 0 L/day shall be used.

[e] If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} or using another appropriate model approved by the Department.

$$\log BCF = 0.76 \log K_{ow} - 0.23$$

where:

Parameter	Definition	Input Value
BCF	Bioconcentration factor (L/kg)	chemical-specific
K_{ow}	Octanol-water partition coefficient	chemical-specific

(Fundamentals of Aquatic Toxicology. 1985. Ed. Rand and S. Petrocelli, Washington: Hemisphere Publishing Corp., Chapter 17, Bioaccumulation, A. Ipacie and J. L. Hamelink)

If a K_{ow} is not available in the literature, a K_{ow} value may be estimated from the K_{oc} using the equation presented below (or other appropriate model):

$$\text{Log } K_{oc} = 0.0784 + (0.7919 \times \log K_{ow})$$

(*Soil Screening Guidance: Technical Background Document*, EPA, 1996).

A2.2.1.2 Noncarcinogenic Health Effects

$$GW_{3NDW} \text{ (mg/l)} = \frac{THQ \times RfD_o \times BW_a}{IRW_{NDW} + (BCF \times IRF)}$$

where:

Parameter	Definition (units)	Input Value
GW$_{3NDW}$	risk-based constituent concentration in water (mg/l)	--
THQ	target hazard quotient (unitless)	1.0 [a]
BW$_a$	average adult body weight (kg)	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]
RfD$_o$	oral reference dose (mg/kg-day)	CS [c]
IRW$_{NDW}$	incidental water ingestion rate (L/day)	0.089 [a,d]
BCF	bioconcentration factor (L/kg)	CS [c,e]

[a]*Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana,* Water Permits Division Office of Environmental Services, LDEQ 2004.

[b]An fish ingestion rate of 0.02 kg/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, a fish ingestion rate of 0.0065 kg/day shall be used.

[c]Chemical-specific

[d]An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, an incidential water ingestion rate of 0 L/day shall be used.

[e]If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K$_{ow}$ or another appropriate model approved by the Department.

A2.2.2 GW$_{3NDW}$

<u>Protection of Surface Water Classified as a Drinking Water Supply</u>

The State human health protection drinking water supply criterion in LAC 33:IX.1113, Table 1 shall be used as the GW$_{3DW}$. If a State human health protection drinking water supply criterion is not available, then the MCL shall be used. If an MCL is not available for a COC, then a risk-based criterion shall be developed using the equation presented below. If applicable criteria shall be calculated for both carcinogenic health effects and noncarcinogenic health effects and the lower of the two values shall be selected as the risk-based criterion. Note: No substitutions shall be made for the input values presented below for the calculation of the GW$_{3DW}$.

A2.2.2.1 Carcinogenic Health Effects

$$GW_{3DW} \text{ (mg/)} = \frac{TR \, x \, BW_a}{SF_o \, x \, [IRW_a + IRW_{NDW} + (BCF \, x \, IRF)]}$$

where:

Parameter	Definition (units)	Input Value
GW$_{3DW}$	risk-based constituent concentration in water (mg/l)	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]
BW$_a$	average adult body weight (kg)	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]
SF$_o$	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [b]
IRW$_a$	adult water ingestion rate (L/day)	2 [a]
IRW$_{NDW}$	incidental water ingestion rate (L/day)	0.089 [a,c]
BCF	bioconcentration factor (L/kg)	CS [b,d]

[a]*Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana,* Water Permits Division Office of Environmental Services, LDEQ 2004.
[b]Chemical-specific
[c]An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion.
[d]If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K$_{ow}$ or another appropriate model approved by the Department.

A2.2.2.2 Noncarcinogenic Health Effects

$$GW_{3DW} \ (\text{mg/l}) = \frac{THQ \, x RfD_o \, x BW_a}{IRW_a + IRW_{NDW} + \left(BCFxIRF \right)}$$

where:

Parameter	Definition (units)	Input Value
GW_{3DW}	risk-based constituent concentration in water (mg/l)	--
THQ	target hazard quotient (unitless)	1.0 [a]
BW_a	average adult body weight (kg)	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]
RfD_o	oral reference dose (mg/kg-day)	CS [b]
IRW_a	adult water ingestion rate (L/day)	2 [a]
IRW_{NDW}	incidental water ingestion rate (L/day)	0.089 [a,c]
BCF	bioconcentration factor (L/kg)	CS [b,d]

[a]*Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana,* Water Permits Division Office of Environmental Services, LDEQ 2004.
[b]Chemical-specific
[c]An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion.
[d]If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} or another appropriate model approved by the Department.

A2.3 Water Solubility

The water solubility ($Water_{sol}$) shall be considered in the identification of the limiting groundwater RS for Groundwater Classifications 1, 2, and 3. A $Water_{sol}$ value used as a RS is subject to Department approval.

A3.0 INDOOR AIR (IA)

The IA shall be based on the Louisiana Toxic Air Pollutant Ambient Air Standards in Table 51.2 of LAC 33:III.5112; if the COC is a noncarcinogen, the 8-hour average ambient air standard shall serve as the IA; if the COC is a carcinogen, the annual average ambient air standard shall serve as the IA. If an Ambient Air Standard is not available for a constituent, then a risk-based value shall be calculated using exposure assumptions for the appropriate land use scenario as presented below. If appropriate for site-specific conditions, other risk-based values may be approved by the Department to serve as the IA.

A3.1 Non-Industrial (Residential) Indoor Air (IA$_{ni}$)

A3.1.1   Carcinogenic Health Effects

$$SL_{res\text{-}air\text{-}ca}\left(\mu g/m^3\right) = \frac{TR \times AT_r\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{EF_r\left(\frac{350\ days}{year}\right) \times ED_r\ (30\ years) \times ET_{ra}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IUR\left(\mu g/m^3\right)^{-1}}$$

A3.1.2 Mutagenic Effects

$$SL_{res\text{-}air\text{-}mu}\left(\mu g/m^3\right) = \frac{TR \times AT_r\left(\frac{365\ days}{year} \times LT\ (70\ years)\right)}{\begin{array}{c} EF_r\left(\frac{350\ days}{year}\right) \times ET_{ra}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times \\[6pt] \left(\begin{array}{l} \left(ED_{0\text{-}2}\ (yrs) \times IUR\left(\mu g/m^3\right)^{-1} \times 10\right) + \left(ED_{2\text{-}6}\ (yrs) \times IUR\left(\mu g/m^3\right)^{-1} \times 3\right) + \\[6pt] \left(ED_{6\text{-}16}\ (yrs) \times IUR\left(\mu g/m^3\right)^{-1} \times 3\right) + \left(ED_{16\text{-}30}\ (yrs) \times IUR\left(\mu g/m^3\right)^{-1} \times 1\right) \end{array}\right) \end{array}}$$

A3.1.3 Vinyl Chloride – Carcinogenic Effects

$$SL_{res-air-ca-vinyl\ chloride}\left(\mu g/m^3\right) = \cfrac{TR}{IUR\left(\mu g/m^3\right)^{-1} + \left(\cfrac{IUR\left(\mu g/m^3\right)^{-1} \times EF_r\left(\cfrac{350\ days}{year}\right) \times ED_r\ (30\ years) \times ET_{ra}\left(\cfrac{24\ hours}{day}\right) \times \left(\cfrac{1\ day}{24\ hours}\right)}{AT_r\left(\cfrac{365\ days}{year} \times LT\ (70\ years)\right)}\right)}$$

A3.1.4   Noncarcinogenic Health Effects

$$SL_{res-air-nc}\left(\mu g/m^3\right) = \cfrac{THQ \times AT_r\left(\cfrac{365\ days}{year} \times ED_r\ (30\ years)\right) \times \left(\cfrac{1000\ \mu g}{mg}\right)}{EF_r\left(\cfrac{350\ days}{year}\right) \times ED_r\ (30\ years) \times ET_{ra}\left(\cfrac{24\ hours}{day}\right) \times \left(\cfrac{1\ day}{24\ hours}\right) \times \cfrac{1}{RfC\left(mg/m^3\right)}}$$

A3.2 Industrial/Commercial Indoor Air (IA$_i$)

A3.2.1   Carcinogenic Health Effects

$$SL_{w\text{-}air\text{-}ca}\left(\mu g/m^3\right)=\frac{TR \times AT_w\left(\dfrac{365\ days}{year}\times LT\ (70\ years)\right)}{EF_w\left(\dfrac{250\ days}{year}\right)\times ED_w\ (25\ years)\times ET_w\left(\dfrac{8\ hr}{24\ hr}\right)\times IUR\left(\mu g\Big/m^3\right)^{-1}}$$

A3.2.2   Noncarcinogenic Health Effects

$$SL_{w\text{-}air\text{-}nc}\left(\mu g/m^3\right)=\frac{THQ \times AT_w\left(\dfrac{365\ days}{year}\times ED_w\ (25\ years)\right)\times\left(\dfrac{1000\ \mu g}{mg}\right)}{EF_w\left(\dfrac{250\ days}{year}\right)\times ED_w\ (25\ years)\times ET_w\left(\dfrac{8\ hr}{24\ hr}\right)\times\dfrac{1}{RfC\left(mg\Big/m^3\right)}}$$

A4.0 SYMBOL DEFINITIONS AND DEFAULT INPUT PARAMETERS

The following table cross-references the Screening Standards and RECAP Standard with the equation nomenclature:

RECAP Standard	Definition (units)	Equation Nomenclature
IA$_{ni}$	Resident Air Carcinogenic (µg/m^3)	**SL$_{res\text{-}air\text{-}ca}$**
	Resident Air Carcinogenic Vinyl Chloride (µg/m^3)	**SL$_{res\text{-}air\text{-}ca\text{-}vc}$**
	Resident Air Mutagenic (µg/m^3)	**SL$_{res\text{-}air\text{-}mu}$**
	Resident Air Noncarcinogenic (µg/m^3)	**SL$_{res\text{-}air\text{-}nc}$**
GW$_{SS}$, GW$_1$ and GW$_2$	**Resident Tapwater Groundwater Carcinogenic Total (µg/L)**	**SL$_{water\text{-}ca\text{-}tot}$**
	• Resident Tapwater Groundwater Carcinogenic Dermal (µg/L)	SL$_{water\text{-}ca\text{-}der}$
	• Resident Tapwater Groundwater Carcinogenic Inhalation (µg/L)	SL$_{water\text{-}ca\text{-}inh}$
	• Resident Tapwater Groundwater Carcinogenic Ingestion (µg/L)	SL$_{water\text{-}ca\text{-}ing}$
GW$_{SS}$, GW$_1$ and GW$_2$	**Resident Tapwater Groundwater Carcinogenic Vinyl Chloride Total (µg/L)**	**SL$_{res\text{-}water\text{-}ca\text{-}vc\text{-}tot}$**
	• Resident Tapwater Groundwater Carcinogenic Vinyl Chloride Dermal (µg/L)	SL$_{res\text{-}water\text{-}ca\text{-}vc\text{-}der}$
	• Resident Tapwater Groundwater Carcinogenic Vinyl Chloride Inhalation (µg/L)	SL$_{res\text{-}water\text{-}ca\text{-}vc\text{-}inh}$
	• Resident Tapwater Groundwater Carcinogenic Vinyl Chloride Ingestion (µg/L)	SL$_{res\text{-}water\text{-}ca\text{-}vc\text{-}ing}$
GW$_{SS}$, GW$_1$ and GW$_2$	**Resident Tapwater Groundwater Mutagenic Total (µg/L)**	**SL$_{water\text{-}mu\text{-}tot}$**
	• Resident Tapwater Groundwater Mutagenic Dermal (µg/L)	SL$_{water\text{-}mu\text{-}der}$
	• Resident Tapwater Groundwater Mutagenic Inhalation (µg/L)	SL$_{water\text{-}mu\text{-}inh}$
	• Resident Tapwater Groundwater Mutagenic Ingestion (µg/L)	SL$_{water\text{-}mu\text{-}ing}$
GW$_{SS}$, GW$_1$ and GW$_2$	**Resident Tapwater Groundwater Noncarcinogenic Total (µg/L)**	**SL$_{water\text{-}nc\text{-}tot}$**
	• Resident Tapwater Groundwater Noncarcinogenic Dermal (µg/L)	SL$_{water\text{-}nc\text{-}der}$
	• Resident Tapwater Groundwater Noncarcinogenic Inhalation (µg/L)	SL$_{water\text{-}nc\text{-}inh}$
	• Resident Tapwater Groundwater Noncarcinogenic Ingestion (µg/L)	SL$_{water\text{-}nc\text{-}ing}$
Soil$_{ssni}$, Soil$_{ni}$	**Resident Soil Carcinogenic Total (mg/kg)**	**SL$_{res\text{-}sol\text{-}ca\text{-}tot}$**
	• Resident Soil Carcinogenic Dermal (mg/kg)	SL$_{res\text{-}sol\text{-}ca\text{-}der}$
	• Resident Soil Carcinogenic Inhalation (mg/kg)	SL$_{res\text{-}sol\text{-}ca\text{-}inh}$
	• Resident Soil Carcinogenic Ingestion (mg/kg)	SL$_{res\text{-}sol\text{-}ca\text{-}ing}$

Soil$_{ssni}$, Soil$_{ni}$	**Resident Soil Carcinogenic Vinyl Chloride Total (mg/kg)**	**SL$_{res-sol-ca-vc-tot}$**
	• Resident Soil Carcinogenic Vinyl Chloride Dermal (mg/kg)	SL$_{res-sol-ca-vc-der}$
	• Resident Soil Carcinogenic Vinyl Chloride Inhalation (mg/kg)	SL$_{res-sol-ca-vc-inh}$
	• Resident Soil Carcinogenic Vinyl Chloride Ingestion (mg/kg)	SL$_{res-sol-ca-vc-ing}$
Soil$_{ssni}$, Soil$_{ni}$	**Resident Soil Mutagenic Total (mg/kg)**	**SL$_{res-sol-mu-tot}$**
	• Resident Soil Mutagenic Dermal (mg/kg)	SL$_{res-sol-mu-der}$
	• Resident Soil Mutagenic Inhalation (mg/kg)	SL$_{res-sol-mu-inh}$
	• Resident Soil Mutagenic Ingestion (mg/kg)	SL$_{res-sol-mu-ing}$
Soil$_{ssni}$, Soil$_{ni}$	**Resident Soil Noncarcinogenic Total (mg/kg)**	**SL$_{res-sol-nc-tot}$**
	• Resident Soil Noncarcinogenic Dermal (mg/kg)	SL$_{res-sol-nc-der}$
	• Resident Soil Noncarcinogenic Inhalation (mg/kg)	SL$_{res-sol-nc-inh}$
	• Resident Soil Noncarcinogenic Ingestion (mg/kg)	SL$_{res-sol-nc-ing}$
Soil$_{ssi}$, Soil$_{i}$	**Composite Worker Soil Carcinogenic Total (mg/kg)**	**SL$_{w-sol-ca-tot}$**
	• Composite Worker Soil Carcinogenic Dermal (mg/kg)	SL$_{w-sol-ca-der}$
	• Composite Worker Soil Carcinogenic Inhalation (mg/kg)	SL$_{w-sol-ca-inh}$
	• Composite Worker Soil Carcinogenic Ingestion (mg/kg)	SL$_{w-sol-ca-ing}$
Soil$_{ssi}$, Soil$_{i}$	**Composite Worker Soil Noncarcinogenic Total (mg/kg)**	**SL$_{w-sol-nc-tot}$**
	• Composite Worker Soil Noncarcinogenic Dermal (mg/kg)	SL$_{w-sol-nc-der}$
	• Composite Worker Soil Noncarcinogenic Inhalation (mg/kg)	SL$_{w-sol-nc-inh}$
	• Composite Worker Soil Noncarcinogenic Ingestion (mg/kg)	SL$_{w-sol-nc-ing}$
Soil$_{SSGW}$, Soil$_{GW1}$, Soil$_{GW2}$, Soil$_{GW3}$	**Soil to groundwater pathway**	**SSL**
Soil$_{sat}$	**Soil Saturation**	**C$_{sat}$**

The following table lists the EPA and LDEQ recommended default input values for the calculation of Screening Standards and RECAP Standards. The EPA default inputs for Soil$_{ssni}$ and Soil$_{ni}$ (Resident); Soil$_{ssi}$ and Soil$_i$ (Composite Worker); Soil$_{SSGW}$, Soil$_{GW1}$ and Soil$_{GW2}$ (Soil to Groundwater) Soil$_{sat}$ (Soil Saturation Limit); GW$_{SS}$, GW$_1$, and GW$_2$ (Tap Water); IA$_{ni}$ (Resident Air); IA$_i$ (Worker Air) were obtained from EPA Region 6/EPA Mid-Atlantic Risk Assessment Screening Level Table (May 2013).

Symbol	Definition (units)	EPA Default	LDEQ Default
SL$_{res-air-ca}$	Resident Air Carcinogenic (µg/m^3)	Constituent-specific	
SL$_{res-air-ca-vc}$	Resident Air Carcinogenic Vinyl Chloride (µg/m^3)	Vinyl Chloride-specific	
SL$_{res-air-mu}$	Resident Air Mutagenic (µg/m^3)	Mutagen-specific	
SL$_{res-air-nc}$	Resident Air Noncarcinogenic (µg/m^3)	Constituent-specific	
SL$_{water-ca-ing}$	Resident Tapwater Groundwater Carcinogenic Ingestion (µg/L)	Constituent-specific	
SL$_{water-ca-der}$	Resident Tapwater Groundwater Carcinogenic Dermal (µg/L)	Constituent-specific	
SL$_{water-ca-inh}$	Resident Tapwater Groundwater Carcinogenic Inhalation (µg/L)	Constituent-specific	
SL$_{water-ca-tot}$	Resident Tapwater Groundwater Carcinogenic Total (µg/L)	Constituent-specific	
SL$_{res-water-ca-vc-ing}$	Resident Tapwater Groundwater Carcinogenic Vinyl Chloride Ingestion (µg/L)	Constituent-specific	
SL$_{res-water-ca-vc-der}$	Resident Tapwater Groundwater Carcinogenic Vinyl Chloride Dermal (µg/L)	Constituent-specific	
SL$_{res-water-ca-vc-inh}$	Resident Tapwater Groundwater Carcinogenic Vinyl Chloride Inhalation (µg/L)	Constituent-specific	
SL$_{res-water-ca-vc-tot}$	Resident Tapwater Groundwater Carcinogenic Vinyl Chloride Total (µg/L)	Constituent-specific	
SL$_{water-mu-ing}$	Resident Tapwater Groundwater Mutagenic Ingestion (µg/L)	Constituent-specific	
SL$_{water-mu-der}$	Resident Tapwater Groundwater Mutagenic Dermal (µg/L)	Constituent-specific	
SL$_{water-mu-inh}$	Resident Tapwater Groundwater Mutagenic Inhalation (µg/L)	Mutagen-specific	
SL$_{water-mu-tot}$	Resident Tapwater Groundwater Mutagenic Total (µg/L)	Constituent-specific	
SL$_{water-nc-ing}$	Resident Tapwater Groundwater Noncarcinogenic Ingestion (µg/L)	Constituent-specific	
SL$_{water-nc-der}$	Resident Tapwater Groundwater Noncarcinogenic Dermal (µg/L)	Constituent-specific	
SL$_{water-nc-inh}$	Resident Tapwater Groundwater Noncarcinogenic Inhalation (µg/L)	Mutagen-specific	
SL$_{water-nc-tot}$	Resident Tapwater Groundwater Noncarcinogenic Total (µg/L)	Constituent-specific	
SL$_{res-sol-ca-ing}$	Resident Soil Carcinogenic Ingestion (mg/kg)	Constituent-specific	

$SL_{res-sol-ca-der}$	Resident Soil Carcinogenic Dermal (mg/kg)	Constituent-specific	
$SL_{res-sol-ca-inh}$	Resident Soil Carcinogenic Inhalation (mg/kg)	Constituent-specific	
$SL_{res-sol-ca-tot}$	Resident Soil Carcinogenic Total (mg/kg)	Constituent-specific	
$SL_{res-sol-ca-vc-ing}$	Resident Soil Carcinogenic Vinyl Chloride Ingestion (mg/kg)	Vinyl Chloride -specific	
$SL_{res-sol-ca-vc-der}$	Resident Soil Carcinogenic Vinyl Chloride Dermal (mg/kg)	Vinyl Chloride-specific	
$SL_{res-sol-ca-vc-inh}$	Resident Soil Carcinogenic Vinyl Chloride Inhalation (mg/kg)	Vinyl Chloride-specific	
$SL_{res-sol-ca-vc-tot}$	Resident Soil Carcinogenic Vinyl Chloride Total (mg/kg)	Vinyl Chloride-specific	
$SL_{res-sol-mu-ing}$	Resident Soil Mutagenic Ingestion (mg/kg)	Mutagen-specific	
$SL_{res-sol-mu-der}$	Resident Soil Mutagenic Dermal (mg/kg)	Mutagen-specific	
$SL_{res-sol-mu-inh}$	Resident Soil Mutagenic Inhalation (mg/kg)	Mutagen-specific	
$SL_{res-sol-mu-tot}$	Resident Soil Mutagenic Total (mg/kg)	Mutagen-specific	
$SL_{res-sol-nc-ing}$	Resident Soil Noncarcinogenic Ingestion (mg/kg)	Constituent-specific	
$SL_{res-sol-nc-der}$	Resident Soil Noncarcinogenic Dermal (mg/kg)	Constituent-specific	
$SL_{res-sol-nc-inh}$	Resident Soil Noncarcinogenic Inhalation (mg/kg)	Constituent-specific	
$SL_{res-sol-nc-tot}$	Resident Soil Noncarcinogenic Total (mg/kg)	Constituent-specific	
$SL_{w-sol-ca-ing}$	Composite Worker Soil Carcinogenic Ingestion (mg/kg)	Constituent-specific	
$SL_{w-sol-ca-der}$	Composite Worker Soil Carcinogenic Dermal (mg/kg)	Constituent-specific	
$SL_{w-sol-ca-inh}$	Composite Worker Soil Carcinogenic Inhalation (mg/kg)	Constituent-specific	
$SL_{w-sol-ca-tot}$	Composite Worker Soil Carcinogenic Total (mg/kg)	Constituent-specific	
$SL_{w-sol-nc-ing}$	Composite Worker Soil Noncarcinogenic Ingestion (mg/kg)	Constituent-specific	
$SL_{w-sol-nc-der}$	Composite Worker Soil Noncarcinogenic Dermal (mg/kg)	Constituent-specific	
$SL_{w-sol-nc-inh}$	Composite Worker Soil Noncarcinogenic Inhalation (mg/kg)	Constituent-specific	
$SL_{w-sol-nc-tot}$	Composite Worker Soil Noncarcinogenic Total (mg/kg)	Constituent-specific	
Toxicity Values			
RfD_o	Chronic Oral Reference Dose (mg/kg-day)	Constituent-specific	Refer to Section 2.4
RfC	Chronic Inhalation Reference Concentration (mg/m^3)	Constituent-specific	Refer to Section 2.4
CSF_o	Chronic oral Slope Factor (mg/kg-day)$^{-1}$	Constituent-specific	Refer to Section 2.4
IUR	Chronic Inhalation Unit Risk (µg/m^3)$^{-1}$	Constituent-specific	Refer to Section 2.4
Miscellaneous Variables			

TR	target risk	1×10^{-6}	Refer to Section 2.5
THQ (Screening Option)	target hazard quotient	0.1	Refer to Section 2.5
THQ (MO-1, 2, 3)	target hazard quotient	1	Refer to Section 2.5
K	Andelman Volatilization Factor (L/m^3)	0.5	
K_p	Dermal Permeability Constant (cm/hr)	Constituent-specific	
AT_r	Averaging time - resident (days/year)	365	
AT_w	Averaging time - worker (days/year)	365	
LT	Lifetime (years)	70	
Ingestion, and Dermal Contact Rates			
IRW_c	Resident Drinking Water Ingestion Rate - Child (L/day)	1	
IRW_a	Resident Drinking Water Ingestion Rate - Adult (L/day)	2	
IFW_{adj}	Resident Drinking Water Ingestion Rate - Age-adjusted (L-year/kg-day)	1.086	
$IFWM_{adj}$	Resident Mutagenic Drinking Water Ingestion Rate - Age-adjusted (L-year/kg-day)	3.39	
IRS_c	Resident Soil Ingestion Rate - Child (mg/day)	200	
IRS_a	Resident Soil Ingestion Rate - Adult (mg/day)	100	
IFS_{adj}	Resident Soil Ingestion Rate - Age-adjusted (mg-year/kg-day)	114	
$IFSM_{adj}$	Resident Mutagenic Soil Ingestion Rate - Age-adjusted (mg-year/kg-day)	489.5	
IR_w	Composite Worker Soil Ingestion Rate (mg/day)	100	
IRS_{0-2}	Soil Ingestion Rate - Age-segment 0-2 (mg/day)	200	
IRS_{2-6}	Soil Ingestion Rate - Age-segment 2-6 (mg/day)	200	
IRS_{6-16}	Soil Ingestion Rate - Age-segment 6-16 (mg/day)	100	
IRS_{16-30}	Soil Ingestion Rate - Age-segment 16-30 (mg/day)	100	
DFS_{adj}	Resident soil dermal contact factor- age-adjusted (mg-year/kg-day)	361	
$DFSM_{adj}$	Resident Mutagenic soil dermal contact factor- age-adjusted (mg-year/kg-day)	1445	
DFW_{adj}	Resident water dermal contact factor- age-adjusted (cm^2 -	8811.4	

	event/kg)		
$DFWM_{adj}$	Resident Mutagenic water dermal contact factor- age-adjusted (cm^2 - event/kg)	Site-specific	
SA_c	Resident soil surface area - child (cm^2)	2800	
SA_a	Resident soil surface area - adult (cm^2)	5700	
SA_c	Resident water surface area - child (cm^2)	6600	
SA_a	Resident water surface area - adult (cm^2)	18000	
SA_{ow}	Worker soil surface area - adult (cm^2)	3300	
SA_{ow}	Worker soil surface area - adult (cm^2)	3300	
SA_{16-30}	Recreator soil surface area - age segment 16-30 (cm^2)	Site-specific	
AF_c	Resident soil adherence factor - child (mg/cm^2)	0.2	
AF_a	Resident soil adherence factor - adult (mg/cm^2)	0.07	
AF_{ow}	Worker soil adherence factor - child (mg/cm^2)	0.2	
BW_c	Resident Body Weight - child (kg)	15	
BW_a	Resident Body Weight - adult (kg)	70	
BW_w	Worker Body Weight (kg)	70	
ABS_d	Fraction of constituent absorbed dermally from soil (unitless)	Constituent-specific	
GIABS	Fraction of constituent absorbed in gastrointestinal tract (unitless) Note: if the GIABS is >50% then it is set to 100% for the calculation of dermal toxicity values.	Constituent-specific	
DA_{event}	Absorbed dose per event ($\mu g/cm^2$ - event)	Constituent-specific	
Exposure Frequency, Exposure Duration, and Exposure Time Variables			
EF_r	Resident Exposure Frequency (days/yr)	350	
EF_w	Worker Exposure Frequency (days/yr)	250	
EF_{0-2}	Exposure Frequency - age segment 0-2 (days/yr)	Site-specific	
EF_{2-6}	Exposure Frequency - age segment 2-6 (days/yr)	Site-specific	
EF_{6-16}	Exposure Frequency - age segment 6-16 (days/yr)	Site-specific	
EF_{16-30}	Exposure Frequency - age segment 16-30 (days/yr)	Site-specific	
ED_r	Resident Exposure Duration (yr)	30	
ED_c	Resident Exposure Duration - child (yr)	6	
ED_a	Resident Exposure Duration - adult (yr)	24	

ED_w	Worker Exposure Duration - (yr)	25	
ED_{0-2}	Exposure Duration - age segment 0-2 (yr)	Site-specific	
ED_{2-6}	Exposure Duration - age segment 2-6 (yr)	Site-specific	
ED_{6-16}	Exposure Duration - age segment 6-16 (yr)	Site-specific	
ED_{16-30}	Exposure Duration - age segment 16-30 (yr)	Site-specific	
ET_{ra}	Resident Air Exposure Time (hours/day)	24	
ET_{rs}	Resident Soil Exposure Time (hours/day)	24	
ET_w	Worker Air Exposure Time (hr/hr)	8	
ET_{ws}	Worker Soil Exposure Time (hours/day)	8	
ET_{rw}	Resident Water Exposure Time (hours/day)	24	
ET_{rwc}	Resident Water Exposure Time - child (hours/event)	1	
ET_{rwa}	Resident Water Exposure Time - adult (hours/event)	0.58	
ET_{0-2}	Exposure Time - age segment 0-2 (hours/event)	Site-specific	
ET_{2-6}	Exposure Time - age segment 2-6 (hours/event)	Site-specific	
ET_{6-16}	Exposure Time - age segment 6-16 (hours/event)	Site-specific	
ET_{16-30}	Exposure Time - age segment 16-30 (hours/event)	Site-specific	
EV_{0-2}	Events - age segment 0-2 (events/day)	Site-specific	
EV_{2-6}	Events - age segment 2-6 (events/day)	Site-specific	
EV_{6-16}	Events - age segment 6-16 (events/day)	Site-specific	
EV_{16-30}	Events - age segment 16-30 (events/day)	Site-specific	
Soil to Groundwater Pathway Variables			
I	Infiltration Rate (m/year)	0.18	0.1
L	source length parallel to ground water flow (m)	site-specific	
i	hydraulic gradient (m/m)	site-specific	
K	aquifer hydraulic conductivity (m/year)	site-specific	
θ_w	water-filled soil porosity (L_{water}/L_{soil})	0.3	0.21
θ_a	air-filled soil porosity (L_{air}/L_{soil})	$= n-\theta_w$	0.15
n	total soil porosity(L_{pore}/L_{soil})	$= 1-(\rho_b/\rho_s)$	0.36
ρ_s	soil particle density (Kg/L)	2.65	2.65

ρ_b	dry soil bulk density (kg/L)	1.5	1.7
H'	Dimensionless Henry Law Constant (unitless)	analyte-specific	
K_d	soil-water partition coefficient (L/kg)	= K_{oc}*f_{oc} for organics	
K_{oc}	soil organic carbon/water partition coefficient (L/kg)	analyte-specific	
f_{oc}	fraction organic carbon in soil (g/g)	0.002	0.006
d_a	aquifer thickness (m)	site-specific	
d_s	depth of source (m)	site-specific	
d	mixing zone depth (m)	site-specific	
Particulate Emission Factor Variables			
PEF_w	Particulate Emission Factor - Minneapolis (m^3/kg)	1.36 x 10^9 (region-specific)	Houston 5.06E+10
Q/C	Inverse of the Mean Concentration at the Center of a 0.5-Acre-Square Source (g/m^2-s per kg/m^3)	93.77 (region-specific)	76.39
V	Fraction of Vegetative Cover (unitless)	0.5	
U_m	Mean Annual Wind Speed (m/s)	4.69	3.49
U_t	Equivalent Threshold Value of Wind Speed at 7m (m/s)	11.32	
F(x)	Function Dependent on U_m/U_t (unitless)	0.194	0.0103
A	Dispersion constant unitless	PEF and region-specific	
A_s	Areal extent of the site or contamination (acres)	0.5 (range 0.5 to 500)	
B	Dispersion constant unitless	PEF and region-specific	
C	Dispersion constant unitless	PEF and region-specific	
Volatilization Factor and Soil Saturation Variables			
VF_s	Volatilization Factor - Los Angeles (m^3/kg)	Constituent-specific	Houston
Q/C_w	Inverse of the Mean Concentration at the Center of a 0.5-Acre-Square Source (g/m^2-s per kg/m^3)	68.81	76.39
D_A	Apparent Diffusivity (cm^2/s)	Constituent-specific	
T	Exposure interval (s)	9.5×10^8	9.5E+08
ρ_b	Dry soil bulk density (g/cm^3)	1.5	1.7
θ_a	Air-filled soil porosity (L_{air}/L_{soil}) (n-θ_w)	0.28	0.15
n	Total soil porosity (L_{pore}/L_{soil}) (1-(ρ_b/ρ_s)	0.43	0.36

θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15	0.21
ρ_s	Soil particle density (g/cm^3)	2.65	2.65
S	Water Solubility Limit (mg/L)	Constituent-specific	
D_{ia}	Diffusivity in air (cm^2/s)	Constituent-specific	
H'	Dimensionless Henry's Law Constant	Constituent-specific	
D_{iw}	Diffusivity in water (cm^2/s)	Constituent-specific	
K_d	Soil-water partition coefficient (L/Kg) ($K_{oc} \times f_{oc}$)	Constituent-specific	
K_{oc}	Soil organic carbon-water partition coefficient (L/Kg)	Constituent-specific	
f_{oc}	Organic carbon content of soil (g/g)	0.006	0.006

A5.0 SUMMER'S MODEL (DF$_{\text{SUMMERS}}$)

The mixing of unimpacted groundwater with impacted infiltration and the resultant concentrations in groundwater are estimated using the Summers Model:

DF$_{\text{Summers}}$:
$$\frac{Q_\rho + Q_a}{Q_\rho} = \frac{C_l}{C_{si}}$$

where:

Parameter	Definition (units)	Input Value
C_{si}	constituent concentration in the groundwater (mg/l or g/m^3)	--
Q_ρ	volumetric flow rate of infiltration (soil pore water) from the AOI into the aquifer (m^3/day)	site-specific (refer below)
Q_a	volumetric flow rate of groundwater (m^3/day)	site-specific (refer below)
C_l	dissolved constituent concentration in the liquid phase (mg/l)	site-specific (refer below)

The volumetric flow rate of infiltration from the AOI into the aquifer:

Q$_\rho$ (m^3/day):   I x S$_W$ x L

where:

Parameter	Definition (units)	Input Value
Q_ρ	volumetric flow rate of infiltration (soil pore water) from the AOI into the aquifer (m^3/day)	site-specific
I	infiltration rate (m/yr)	site-specific (0.1) [a]
S_W	source width perpendicular to groundwater flow (m)	site-specific
L	length of impacted area parallel to flow direction of aquifer (m)	site-specific

[a]*Soil Screening Guidance, User's Guide*, EPA 1996.

The volumetric flow rate of the groundwater is estimated as:

Q_a (m³/day): $D_v \times S_d \times S_W$

where:

Parameter	Definition (units)	Input Value
Q_a	volumetric flow rate of groundwater (m³/day)	--
D_v	groundwater darcy velocity in the aquifer (K x i) (m/yr)	site-specific (9.144 m/yr)
S_d	source thickness (i.e., the thickness of the impacted groundwater within the permeable zone) (m)	refer below
S_W	width of impacted area perpendicular to flow direction of aquifer (m)	site-specific

The aqueous-phase concentration (C_l) is estimated from the total soil concentration (C_{Tw}) as follows:

C_l (mg/l): $\quad C_{Tw}\left(\dfrac{[(\rho_w x\theta_w)+\rho_b]}{\rho_b K_d + \theta_w + (1-\theta_w)xH'}\right)$

where:

Parameter	Definition (units)	Input Value
C_l	dissolved constituent concentration in the liquid phase (mg/l)	--
C_{Tw}	total soil concentration on a wet weight basis (mg/kg)	site-specific
ρ_w	density of water (g/cm³)	1.0
ρ_b	dry bulk density of soil (g/cm³)	site-specific (1.7) [a]
ρ_s	soil particle density (g/cm³)	site-specific (2.65) [a]
n	total porosity of soil (L_{pore}/L_{soil})	site-specific (1 - ρ_b/ρ_s)
θ_w	water filled soil porosity (L_{water}/L_{soil})	site-specific (0.21) [a]
K_{oc}	soil organic carbon partition coefficient (cm³/g)	chemical specific
f_{oc}	fractional organic carbon in soil = percent organic matter /174 (g/g) (ASTM 2974)	site-specific (0.006) [a]
K_d	soil water partition coefficient = $K_{oc} \times f_{oc}$ (cm³/g)	chemical-specific
H'	Henry's Law Constant (dimensionless)	chemical-specific [b]

[a]LDEQ default value.
[b]$H' = H \times 41$ where: H = Henry's Law Constant (atm-m³/mol); R = Universal Law Constant (0.0000821 atm-m³/mole-°K); and T = Absolute temperature of soil (°K) [273 + °C (25°C)].

A6.0 DOMENICO MODEL (DF$_{DOMENICO}$)

Before site-specific DF$_{Domenico}$ values are developed using the Domenico model equation presented below, the boundary conditions used to derive this equation shall be reviewed to determine if all of the assumptions are appropriate for the case being modeled (see reference) [a]. The Department will only allow the use of a DF$_{Domenico}$ that is based on the modeling of an infinite permeable zone to a distance of 2000 feet if constituent retardation and first-order degradation rate values are set to LDEQ default values (an equivalent situation was provided to typical UST sites). Otherwise, site-specific conditions (geological conditions) are to be taken into account in the model equation. If there is the potential for constituent migration to be influenced by pumping activities within the zone, a site-specific DF shall not be calculated using the Domenico model. The Submitter may develop a site-specific DF using an appropriate model under MO-3.

DF$_{Domenico}$ [a]:
$$\frac{C_{si}}{C_{(x)_i}} = 1 / \left(\exp\left[\frac{x}{2\alpha_x}\left[1 - \sqrt{1 + \frac{4\lambda_i \alpha_i x R_i}{v}} \right] \right] \left(erf\left[\frac{S_w}{4\sqrt{\alpha_y x}} \right] \right)\left(erf\left[\frac{S_d}{2\sqrt{\alpha_z x}} \right] \right) \right)$$

where:

Parameter	Definition	MO-1	MO-2 or MO-3
$C_{(x)i}$	concentration of constituent i in groundwater at distance x downstream of source (mg/L) or (mg/m^3)	--	--
C_{si}	concentration of constituent i in source zone (mg/L) or (mg/m^3)	--	--
S_w	source width perpendicular to groundwater flow (m)	45 [b]	SS [c]
D_v	groundwater Darcy velocity (K x i) (m/yr)	9.1 [d]	SS [c] (9.1)
n	total soil porosity (L$_{pore}$/L$_{soil}$))	0.36 [d]	SS [c] (1-ρ_b/ρ_s)
λ_i	first-order degradation rate for constituent i (day^{-1})	0 [d]	SS [c,e] (0)
R_i	constituent retardation factor (dimensionless)	1 [d]	SS [c,e] (1)
i	hydraulic gradient (dimensionless)	--	SS [c]
v	groundwater seepage velocity (m/yr)	25.4	(K x i)/n
x	distance downgradient from source (m)	SS [c]	SS [c]
K	hydraulic conductivity (m/yr)		SS [c]
α_x	longitudinal groundwater dispersivity (m)	(x * 0.1)	(x * 0.1)

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α_y	transverse groundwater dispersivity (m)	$(\alpha_x / 3)$	$(\alpha_x / 3)$
α_z	vertical groundwater dispersivity (m)	$(\alpha_x / 20)$ or L/200	$(\alpha_x / 20)$ or L/200
erf	error function; $erf\chi = \frac{2}{\sqrt{\pi}} \int_0^\chi e^{-t^2} dt$	refer below	refer below
S_d	source thickness (i.e., the thickness of the impacted groundwater within the permeable zone) (m)	SS [c,f]	SS [c,f]
ρ_b	dry soil bulk density (g/cm^3)	1.7 [d]	SS (1.7) [d]
ρ_s	soil partical density (g/cm^3)	2.65 [d]	SS (2.65) [d]

[a]Domenico, P.A. and F.W. Schwartz, 1990. *Physical and Chemical Hydrogeology,* John Wiley and Sons, New York, N.Y.
[b]Based on a 0.5 acre source.
[c]Site-specific.
[d]LDEQ default value.
[e]Degradation and/or retardation shall only be included in the model when site-specific quantitative data documents occurrence and the DF is being generated for a MNA program. Derivation of constants for these processes shall be included with the model input data. Degradation and retardation data are by definition monitored natural attenuation processes. Therefore, literature values for retardation and degradation are not acceptable under the RECAP.
[f] Estimation of S_d using Method 1 or 2 as presented below.

The **S_d** is defined as the thickness of the contaminated groundwater within the permeable zone. Refer to Figure _____ for an illustration of S_d.

For the purpose of developing a $DF_{Domenico}$ for GW_2, LDEQ requires that the S_d be estimated using Method 1 or 2. If the estimated S_d value exceeds the aquifer thickness, S_d should be set to the thickness of the aquifer.

Method 1: Sum of advective and dispersive depths:

$S_d = h_{adv} + h_{disp}$

where:

Parameter	Definition (units)	Input Value
S_d	source thickness (i.e., the thickness of the impacted groundwater within the permeable zone) (m)	--
h_{adv}	advective component of the plume depth (m)	site-specific
h_{disp}	dispersive component of the plume depth (m)	Site-specific

$$h_{adv} = B[1-\exp((-I \times L)/(B \times D_v))]$$

where:

Parameter	Definition (units)	Input Value (Default Value)
h_{adv}	advective component of the plume depth (m)	site-specific
I	infiltration rate (m/yr)	site-specific (0.1) [a]
D_v	Darcy groundwater velocity (K x i) (m/yr)	site-specific (9.144) [a]
B	thickness of the shallow water bearing zone (m)	site-specific (< 6.1) [a]
L	length of the source parallel to the groundwater flow at the water table (m)	site-specific

[a]LDEQ default value.

$$h_{disp} = (2 \times \alpha_z \times L)^{1/2}$$

where:

Parameter	Definition (units)	MO-2 Input Value (Default Value)
h_{disp}	dispersive component of the plume depth (m)	site-specific
α_z	vertical groundwater dispersivity (m)	site-specific ($\alpha_x/20$) or (L/200) [a]
L	length of the source parallel to the groundwater flow at the water table (m)	site-specific

Method 2: Thickness of the aquifer

The thickness of the impacted permeable zone shall be used as the S_d if the thickness of the groundwater plume is not known.

SOLUTION TO THE ERROR FUNCTION

χ	erf χ
0.00	0.000 000
0.05	0.056 372
0.10	0.112 463
0.15	0.167 996
0.20	0.222 703
0.25	0.276 326
0.30	0.328 627
0.35	0.379 382
0.40	0.428 392
0.45	0.475 482
0.50	0.520 500
0.55	0.563 323
0.60	0.603 856
0.65	0.642 029
0.70	0.677 801
0.75	0.711 156
0.80	0.742 101
0.85	0.770 668
0.90	0.796 908
0.95	0.820 891
1.00	0.842 701

χ	erfχ
1.1	0.880 205
1.2	0.910 314
1.3	0.934 008
1.4	0.952 285
1.5	0.966 105
1.6	0.976 348
1.7	0.983 790
1.8	0.989 091
1.9	0.992 790
2.0	0.995 322
2.2	0.998 137
2.4	0.999 311
2.6	0.999 764
2.8	0.999 925
3.0	0.999 978
3.2	0.999 994
3.4	0.999 998
3.6	1.000 000
3.8	1.000 000
$\geq$ 4.0	1.000 000

A7.0 DOCUMENTATION FOR SS AND MO-1 RS

The $Soil_{ssni}$, $Soil_{ssi}$, $Soil_{ni}$, $Soil_i$, $Soil_{SSGW}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{sat}$, GW_{SS}, GW_1, and GW_2, where applicable, were calculated in accordance with this appendix. The SS and RS for total petroleum hydrocarbon components are based on the toxicity values and physical/chemical parameters presented in Appendix D.

The GW_3 equations and input parameters were obtained from *Standard Operating Procedure for Human Health Criteria Calculations for Toxic Substance in Louisiana,* Water Permits Division Office of Environmental Services, LDEQ 2004.
and are consistent with LAC 33:IX.1113, Table 1. The GW_3 and $SoilGW_3$ were calculated using the 2003 LDEQ spreadsheet.

AT THE TIME THE SS, MO-1 RS AND UST MO-2 RS ARE CALCULATED, THE TOXICITY VALUES AND PHYSICAL /CHEMICAL INPUTS SUPPORTING THOSE VALUES WILL BE DOWNLOADED AND INCLUDED IN THIS SECTION.